

SILVER-TEFLON CONTAMINATION UV RADIATION STUDY⁺

J. A. MUSCARI, MARTIN MARIETTA AEROSPACE
S. JACOBS, NASA/JOHNSON SPACE CENTER

1.0 INTRODUCTION

Silver-Teflon is currently being planned to be used as the thermal control material covering the radiator surfaces on the Shuttle Orbiter payload bay doors. These radiators require the use of materials that have a very low solar absorptance (α_s) and a high emittance for heat rejection. However, operationally, materials used on these critical radiator surfaces, such as silver-Teflon, will be exposed to a variety of conditions which include both the natural as well as the induced environments. It is very important to understand the influences of these environments upon these materials because of their impact upon on-orbit operational activities as well as ground operations such as refurbishment.

Although radiator surfaces are selected to be stable when exposed to the natural solar ultraviolet and particulate environment, the deposition of contaminants and the interaction of the contaminants with solar exposure can significantly degrade the performance of such an operational surface. Laboratory test programs and spacecraft experiments have shown that certain contaminants darken significantly when exposed to solar ultraviolet, resulting in an increased α_s .

With the present requirement to maintain changes in reflectance on Orbiter radiator surfaces to less than 1%, it becomes very important to understand the nature of spacecraft contaminants when exposed to a solar environment and their effect upon silver-Teflon. The purpose of this study is to determine the effects of radiation upon silver-Teflon surfaces after contamination by the CVCN (collected volatile condensable mass) from RTV-560 and MIL-H-83282 hydraulic fluid. The test procedure was depositing, irradiating, and measuring solar absorptance changes (via reflectance measurements) in-situ. Additionally, cleaning procedures will be developed for surfaces that experience a change in solar absorptance (α_s) greater than 0.03 so that the absorptance can be recovered to near 0.08. This program is still in progress and this paper presents the current results with RTV-560.

2.0 EQUIPMENT

Figure 1 presents a schematic of the test setup and facility. The equipment consists of an ultrahigh vacuum chamber with feedthroughs, manipulators, and LN₂ shroud; contaminant source holder heated by filament lamps; a receptor holder to position nine silver-Teflon (Ag/FEP) samples, a control Ag/FEP sample, and the barium sulfate calibration

⁺ This work was supported by National Aeronautics and Space Administration Johnson Space Center, Houston, Texas, under contract NAS9-15436.

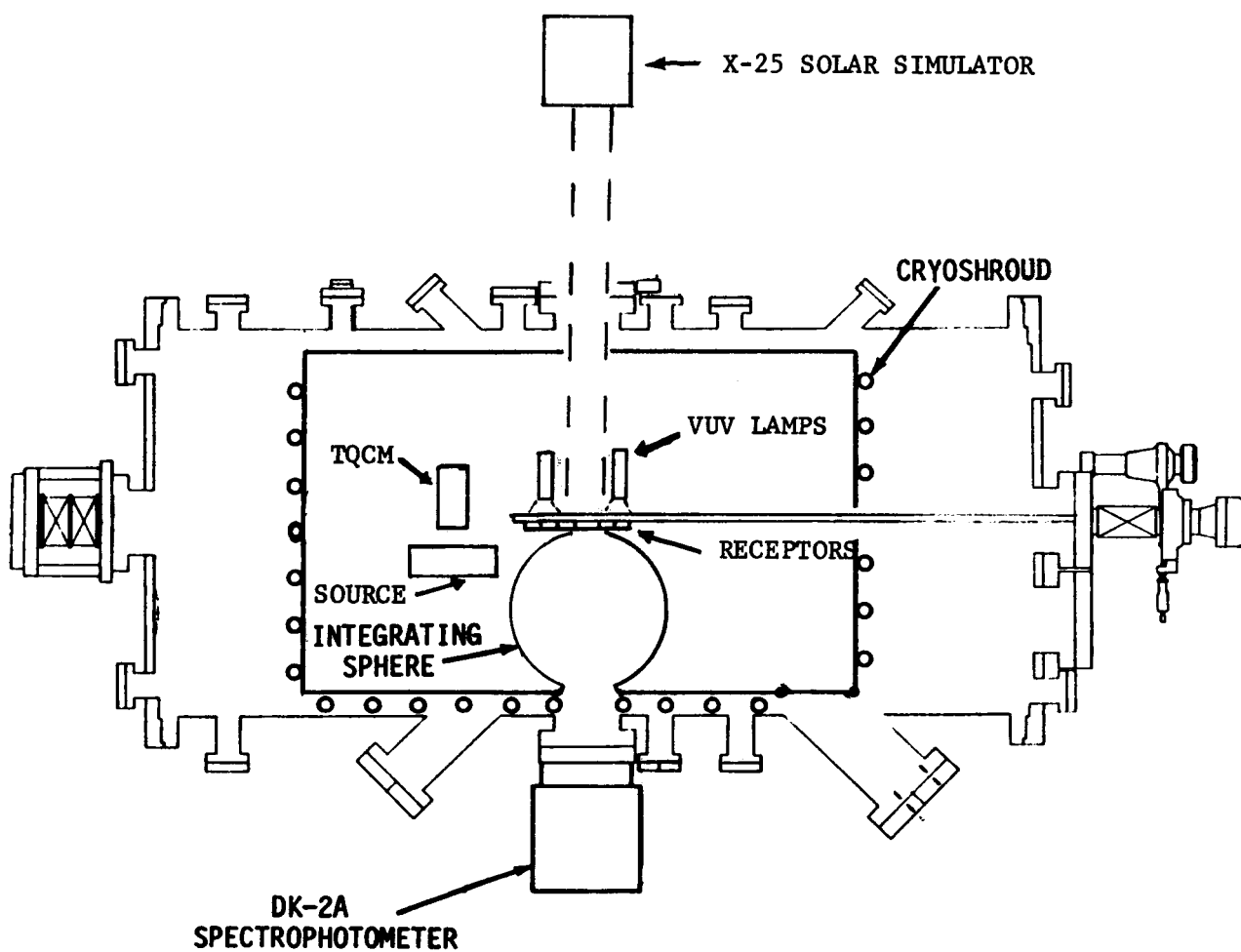


Figure 1 Schematic of the Test Setup and Facility

sample for deposition, irradiation, and measurement; a spectrophotometer with an integrating sphere mounted in the chamber; a solar simulator; two vacuum ultraviolet lamps; and a temperature controlled quartz crystal microbalance (TQCM).

The vacuum chamber normally operated in the low 10^{-6} Torr range. The LN₂ shroud prevented migration of any contaminants to the Ag/FEP except through direct line-of-sight from the test source. The shroud also cooled the Ag/FEP samples by radiation and maintained the contaminated samples below -40°C to inhibit any significant reemission. The TQCM was used to monitor the deposition and any reemission. Thermocouples were used to record the temperatures of the source, Ag/FEP samples, TQCM, spectrophotometer detector system, and the shroud.

The RTV-560 source material was painted onto a 32.3 cm² aluminum plate which was mounted to the holder frame. The back side of the holder frame was heated by three quartz envelope filament lamps and a thermocouple was embedded into the RTV-560 material. RTV-560 is a two-component room temperature vulcanizing silicone rubber produced by General Electric. RTV-560, a methyl-phenyl compound, was prepared using 0.5% of dibutyl tin dilaurate catalyst which corresponded to the mixture for the TML/CVCM tests performed by NASA Goddard. The RTV-560 samples were cured for seven days at room temperature.

The receptor holder positions all nine of the Ag/FEP samples in front of the outgassing source, in front of the exit port in the wall of the integrating sphere, and is then rotated to face the solar simulators. A control sample of Ag/FEP is used to verify sample stability, sphere alignment, and overall system performance. A barium sulfate sample (the walls of the sphere are also coated with barium sulfate) is used to obtain a 100% reading before and after each set of measurements. Both the control and the 100% sample are protected from the outgassing source and the solar simulator beams.

A dual beam spectrophotometer sends two light beams through the quartz window of the vacuum chamber into the integrating sphere where the reference beam strikes the diffuse sphere wall and the multireflected light is collected by the detector system. The second beam strikes the sample which is tilted at an angle of four degrees so that the specular scattered light does not exit through the entrance port and is scattered throughout the sphere. The sample and the reference signals are electronically ratioed, displayed on a chart recorder, and converted to digital data for storage on punch cards. The digital data is processed by the use of computer programs. A blocking screen covered with barium sulfate prevents the specular Ag/FEP samples from direct line-of-sight to the detectors which would give incorrect signals.

An external X-25 solar simulator provides solar intensities up to 2.5 equivalent suns (ES) at target samples 2A, 2B, and 2C after passing through a quartz vacuum chamber window. However, these standard high-pressure xenon lamps are depleted in the short wavelengths radiation (less than 230 nm) which have been shown to be necessary for changes in

certain films.¹ Thus, two in-situ vacuum ultraviolet sources were included to irradiate three samples each. The xenon lamp has 90% of its total radiation (0.621 mW) in the wavelength band of 145 nm to 160 nm. This lamp provides $0.359 \text{ mW}\cdot\text{cm}^{-2}$ at one Ag/FEP sample and $0.0081 \text{ mW}\cdot\text{cm}^{-2}$ at two other samples. If it is assumed that one equivalent ultraviolet sun (EUVS) is the integrated standard solar zero air mass intensity for all wavelengths shorter than 230 nm ($0.131 \text{ mW}\cdot\text{cm}^{-2}$),² then the xenon lamp irradiates sample 1B with 2.74 EUVS and samples 1A and 1C with 0.062 EUVS. An in-situ hydrogen lamp failed during the testing and was replaced by a krypton resonance line lamp (124 nm; $0.166 \text{ mW}\cdot\text{cm}^{-2}$) which produces about 1.3 EUVS on samples 3A, 3B, and 3C.

The TQCM, with a mass sensitivity of $3.5 \times 10^{-9} \text{ g}\cdot\text{cm}^{-2}\cdot\text{Hz}^{-1}$, was kept at the same temperature as the Ag/FEP samples. The characteristics of the matched set of 10 MHz quartz crystals have been tested previously and are known to be relatively insensitive to temperature changes ($+1.5 \text{ Hz}\cdot^{\circ}\text{C}^{-1}$) and have a low response to thermal radiation from heated sources (-7 Hz for a 125°C source). If it is assumed that the CVCM is a uniform film and its density is $1.2 \text{ g}\cdot\text{cm}^{-3}$, then a change of 340 Hz is equivalent to a film of 10 nm.

3.0 TEST PROCEDURES

The stability of Ag/FEP to a vacuum environment and solar radiation, especially vacuum ultraviolet wavelengths, was first verified. Then the effect of the CVCM from RTV-560 and hydraulic fluid for five different CVCM thicknesses will be measured. The reflectance measurements are repeated after irradiating with solar radiation for periods of at least 48 hours up to 300 ESH. The 48 hour baseline correlates to near 48 orbits on the average, or a three day exposure for normal incidence during sunlight periods of the orbit. For surfaces not normal to the solar flux, the time to accumulate 48 hours of sunlight is increased by dividing by $\cos \theta$ where θ is the angle with respect to the surface normal and the incident flux direction. For example, for a surface at 60 degrees, 48 ESH equates to 6 days on orbit and for 45 degrees it is 4.2 days. A current estimate of the expected initial deposition rate on the Ag/FEP surfaces of the Shuttle Orbiter (fixed attitude, flying nose first belly up in a fixed ZLV mode,² zero degree beta angle, and at 296 km) is in the range $1.7 \times 10^{-6} \text{ g}\cdot\text{cm}^{-2}\cdot\text{day}^{-1}$; assuming a CVCM density of $1.2 \text{ g}\cdot\text{cm}^{-3}$ gives a film thickness of $14 \text{ nm}\cdot\text{day}^{-1}$.³ Our planned range of CVCM deposition levels will be equivalent to a thickness from 10 nm to 400 nm and thus cover mission durations up to 30 days.

General cleaning techniques using solvents will be used to study the restoration of degraded Ag/FEP samples. Successful techniques will be reviewed for application to very large surfaces. The reflectance will be

¹P. D. Fleischauer and L. Tolentino, 7th Conf. Space Simulation, NASA SP-336, 645 (1973).

²M. P. Thekaekara, Optical Spectra, 32 (March, 1972).

³R. O. Rantanen and D. A. Strange, Shuttle Orbiter-IUS/DSP Satellite Interface Contamination Study Final Report, MCR-78-512 (January, 1978).

remeasured to verify the original absorptance value or determine the ineffectiveness of the solvent.

4.0 RESULTS

After performing the initial tests, it became quite apparent that standard spectrophotometer techniques would not provide the resolution and repeatability necessary for the low solar absorptance of the Ag/FEP samples. With the typical solar absorptance for Ag/FEP of 0.08 and our computed solar intensity of $1310 \text{ W}\cdot\text{m}^{-2}$ (wavelength region from $0.25 \mu\text{m}$ to $2.5 \mu\text{m}$), then a deviation of only 2% in the reflectance produces a change of 25% in α_s . Table 1 presents the solar absorptance values for the clean Ag/FEP samples verifying the stability of the surfaces to solar radiation.

Table 1 Solar Absorptance of Ag/FEP Samples When Exposed To A Solar Simulator (2.32 ES, Samples 2A,2B,2C), Xenon Lamp (0.062 EUVS, Samples 1A,1C; 2.74 EUVS, Sample 1B), and No Radiation (Control, 3A,3B,3C).

SAMPLE	SOLAR ABSORPTANCE				
	HOURS OF EXPOSURE				AVERAGE STANDARD DEVIATION
	0	25.83	44.58	66.58	
CONTROL	0.076	0.054	0.069	0.060	0.065 ± 0.0097
3A	0.073	0.057	0.070	0.056	0.064 ± 0.0088
3B	0.071	0.054	0.065	0.052	0.061 ± 0.0090
3C	0.064	0.053	0.064	0.054	0.059 ± 0.0061
2A	0.065	0.055	0.064	0.055	0.060 ± 0.0055
2B	0.068	0.063	0.074	0.057	0.066 ± 0.0072
2C	0.076	0.075	0.080	0.070	0.075 ± 0.0041
1A	0.091	0.084	0.096	0.087	0.089 ± 0.0052
1B	0.100	0.093	0.103	0.095	0.098 ± 0.0046
1C	0.114	0.110	0.116	0.110	0.112 ± 0.0030

The values of solar absorptance are only relative due to an as yet undetermined geometrical factor. The average standard deviation for all ten runs is ± 0.0063 .

Eight repeated runs were performed on the control sample, moving and rotating the rod between measurements. The standard deviation for all eight runs was 0.0043 showing the repeatability of the measuring system.

Table 2 presents the data for the change in α_s for the Ag/FEP samples after they were contaminated by the CVCM from RTV-560 with an initial deposit of $2.54 \times 10^{-5} \text{ g}\cdot\text{cm}^{-2}$ and allowed to reemit until 3.32×10^{-6}

$\text{g}\cdot\text{cm}^{-2}$ (equivalent to about 28 nm) remained. The samples were then irradiated up to 49 hours. During this period the TQCM slowly lost mass reaching $2.54\times 10^{-6} \text{ g}\cdot\text{cm}^{-2}$ after 49 hours. The temperatures of the TQCM and the samples were usually in the -80°C range with short excursions to -10°C . Thus, the data in Table 2 is complicated by the fact that any increases in α_s due to ultraviolet radiation may be masked by the decrease in contaminant thickness. The data up to the first 27.25 hrs of exposure shows no significant change in α_s except for samples 2A, 2B, and 2C. These samples show a decrease in α_s , probably due to the decreasing contaminant thickness. Solar radiation does not appear to affect the CVCN. After 27.25 hours of exposure, the data is inconclusive and is being studied further. The data at 49 hours is shown for completeness, but should not be taken as indicating a trend. The radiation was continued out to 147 hours, however, the TQCM frequency dropped to about 50 Hz when the temperature of the samples accidentally reached 0°C . The solar absorptance of the samples returned essentially to the clean values. No discoloration or any other physical defects were observed on the samples after removing them from the vacuum chamber.

Table 2 Change in Solar Absorptance of Silver-Teflon Samples Contaminated by the CVCN of RTV-560 and Exposed to a Solar Simulator (2.32 ES, Samples 2A,2B,2C), Xenon Lamp Radiation 147 nm (0.062 EUVS, Samples 1A,1C; 2.74 EUVS, Sample 1B), and no Radiation (Control, 3A,3B,3C). The Initial Deposition on the TQCM was $2.54\times 10^{-5} \text{ g}\cdot\text{cm}^{-2}$ and was Allowed to Reemit Until $3.32\times 10^{-6} \text{ g}\cdot\text{cm}^{-2}$ (Equivalent to 28 nm) Remained.

SAMPLE	CLEAN α_s	CHANGE IN SOLAR ABSORPTANCE			
		HOURS OF EXPOSURE			
		0.0	21.0	27.25	49.0
3A	0.056	0.002	0.006	-0.001	0.012
3B	0.052	0.003	0.008	-0.002	0.022
3C	0.054	0.001	0.008	-0.003	0.026
2A	0.055	0.011	0.015	0.010	0.034
2B	0.057	0.025	0.017	0.012	0.038
2C	0.070	0.024	0.013	0.015	0.034
1A	0.087	0.007	0.008	0.008	0.031
1B	0.095	0.016	0.006	0.009	0.027
1C	0.110	0.017	0.004	-0.006	0.029

The TRASYS computer program was used to calculate the ratio of each sample/source view factor to the TQCM/source view factor to verify the uniformity of contaminant deposition. Table 3 shows this view factor ratio.

Table 3 Ratio of Sample/Source View Factor to the TQCM/Source View Factor

SAMPLE	$(VF_S)/(VF_{TQCM})$
3A	0.94
3B	0.97
3C	0.99
2A	1.00
2B	1.00
2C	1.00
1A	0.99
1B	0.97
1C	0.94

Table 4 shows the data for the change in α_s for the samples contaminated with an initial deposit of $4.06 \times 10^{-5} \text{ g.cm}^{-2}$ (equivalent to 340 nm), decreasing to $3.45 \times 10^{-5} \text{ g.cm}^{-2}$ and remaining relatively constant throughout the 134.98 hour test period ending at $3.12 \times 10^{-5} \text{ g.cm}^{-2}$. The number in parenthesis below each exposure time is the frequency of the TQCM above its initial clean value. The temperature control of the LN_2 shroud was improved, resulting in the samples and the TQCM staying at about $-46^\circ\text{C} \pm 5^\circ\text{C}$. The temperature of samples 2A, 2B, and 2C was continuously monitored during the entire test period. The data in Table 4 indicates that both the solar beam and the vacuum ultraviolet radiation had little effect on the CVCM/FEP/Ag surface and the initial change in α_s decreased as the thickness of the CVCM decreased. Samples 3A, 3B, and 3C which were not exposed to any radiation show the same decrease in α_s as the exposed samples. Also, samples 1A and 1C which were exposed to 8.37 EUVSH show the same change in α_s as 1B which was exposed to 370 EUVSH. Figure 2 presents the change in α_s as a function of time, illustrating the similar decrease in α_s for these example samples. Once again, when the TQCM was brought up to room temperature only a very small residual CVCM remained. The samples were also visibly the same as their initial condition.

Table 5 presents the change in α_s when contaminated by the CVCM deposited sequentially in five steps to a total of $4.46 \times 10^{-5} \text{ g.cm}^{-2}$. The data shows an unexpected decrease in α_s from the clean condition. The maximum temperature of the RTV-560 source, T_s , started at 33°C for the first layer and reached 65°C for the last step. The maximum temperature of the silver-Teflon samples during deposition was -10°C , nominal temperature was -51°C .

The samples used in the above test ($4.46 \times 10^{-5} \text{ g.cm}^{-2}$) were then irradiated up to 85.41 hours and the data is shown in Table 6. Once again, even for this heavier coating of CVCM, radiation exposure does not significantly affect the contaminated surface α_s . Figure 3 shows a photograph (22x magnification) of the contaminated area (atmospheric pressure, 25°C) for samples 1A, 1B, and 1C; 1C is the area to the left of center,

Table 4 Change in Solar Absorptance of Silver-Teflon Samples Contaminated by the CVCN of RTV-560 and Exposed to a Solar Simulator and Xenon Lamp. The Initial Deposition on the TQCM was $4.06 \times 10^{-5} \text{ g} \cdot \text{cm}^{-2}$ and After 134.98 Hours $3.12 \times 10^{-5} \text{ g} \cdot \text{cm}^{-2}$ Remained. The Number in Parenthesis Below the Hours of Exposure is the Frequency of the TQCM above the Initial Clean Condition

SAMPLE	CHANGE IN SOLAR ABSORPTANCE							
	HOURS OF EXPOSURE							
	0.0 (11602)	17.23 (9855)	22.23 (9507)	38.37 (9427)	60.48 (9288)	65.98 (9265)	84.73 (8943)	134.98 (8926)
3A	0.024	0.011	0.010	0.015	0.017	0.010	0.016	-0.001
3B	0.013	0.018	0.020	0.019	0.045	0.022	0.026	0.020
3C	0.001	0.005	0.008	0.008	0.025	0.010	0.014	0.005
2A	0.011	0.006	0.011	0.011	0.023	0.009	0.010	-0.003
2B	0.025	0.013	0.017	0.018	0.033	0.014	0.018	0.001
2C	0.021	0.012	0.016	0.014	0.033	0.014	0.012	-0.001
1A	0.028	0.030	0.023	0.026	0.045	0.026	0.015	0.011
1B	0.042	0.034	0.022	0.028	0.052	0.030	0.016	0.019
1C	0.046	0.044	0.030	0.022	0.053	0.032	0.026	0.023

Table 5 Change in Solar Absorptance of Silver-Teflon Samples Contaminated by the CVCN of RTV-560 Sequentially in Five Steps to a Total of $4.46 \times 10^{-5} \text{ g} \cdot \text{cm}^{-2}$. The Change in Solar Absorptance is From the Initial Clean Value. The Sensitivity of the TQCM is $3.5 \times 10^{-9} \text{ g} \cdot \text{cm}^{-2} \cdot \text{Hz}^{-1}$.

SAMPLE	CHANGE IN SOLAR ABSORPTANCE				
	(TQCM FREQUENCY IN Hz)				
	(1088)	(2558)	(3873)	(8176)	(12742)
3A	-0.014	0.000	-0.004	-0.013	-0.019
3B	-0.009	-0.003	-0.011	-0.029	-0.027
3C	-0.011	-0.006	-0.020	-0.037	-0.036
2A	-0.011	-0.010	-0.021	-0.040	-0.040
2B	-0.006	-0.006	-0.019	-0.039	-0.037
2C	-0.007	-0.007	-0.024	-0.033	-0.033
1A	-0.014	-0.003	-0.020	-0.041	-0.043
1B	-0.031	-0.027	-0.028	-0.049	-0.051
1C	-0.046	-0.036	-0.038	-0.060	-0.070
T _s	33°C	37°C	40°C	57°C	65°C

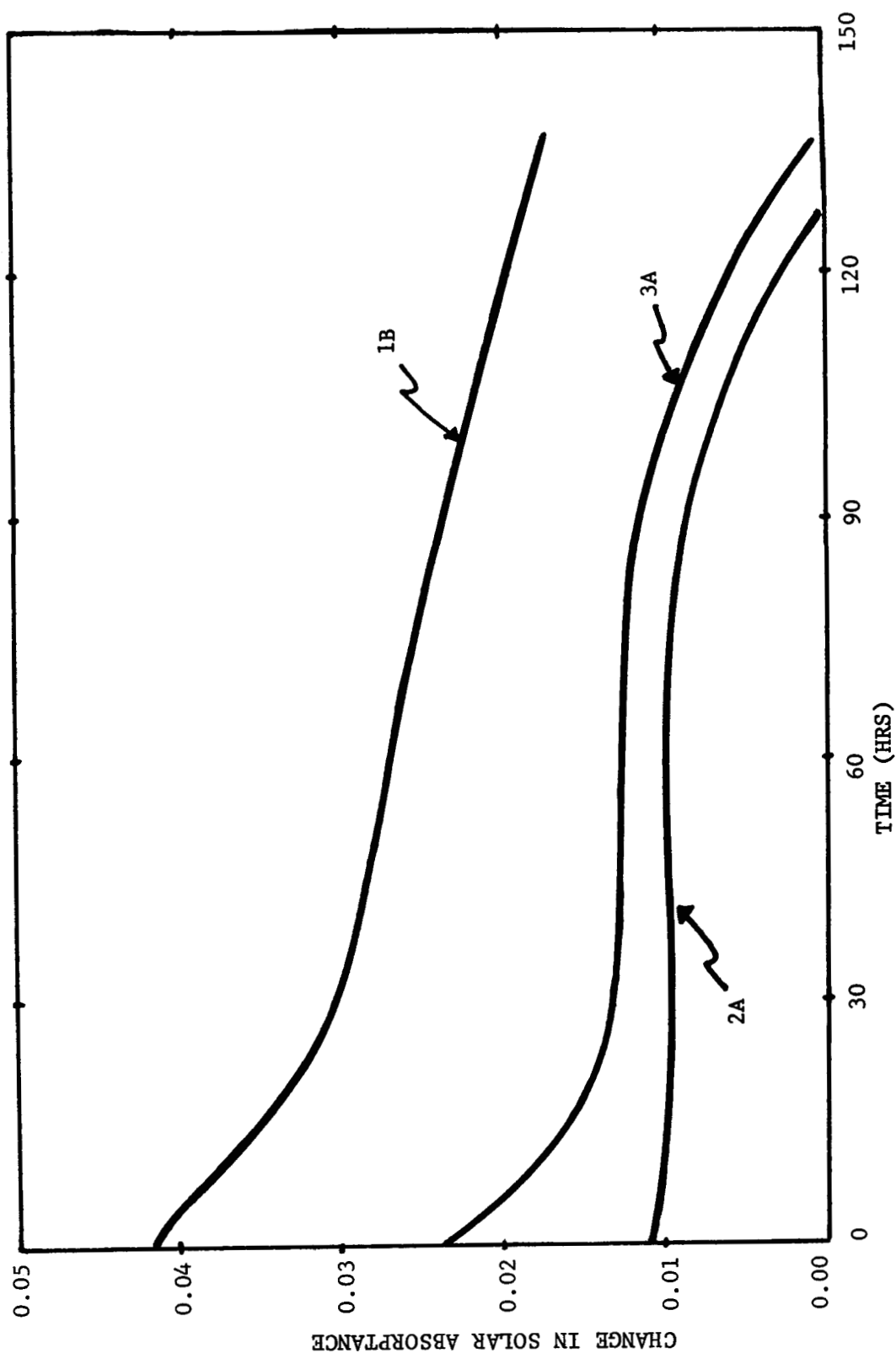


Figure 2 Change In Solar Absorptance Of Contaminated (CVCN From RTV-560) Silver-Teflon When Exposed To No Radiation (3A), X-25 Solar Simulator (2A, 2.32 ES), And Vacuum Ultraviolet

Table 6 Change in Solar Absorptance of Silver-Teflon Samples Contaminated by the CVCN of RTV-560 and Exposed to no Radiation (3A,3B,3C), Solar Radiation (2A,2B,2C 2.32 ES), and to a Xenon Lamp 147 nm (1B 2.74 EUVS; 1A,1C 0.062 EUVS). The Initial Deposition on the TQCM was $4.46 \times 10^{-5} \text{ g} \cdot \text{cm}^{-2}$ and After 85.41 Hours $4.44 \times 10^{-5} \text{ g} \cdot \text{cm}^{-2}$ Remained. The Change in Solar Absorptance is From the Contaminated Condition Zero Hours Radiation.

SAMPLE	CHANGE IN SOLAR ABSORPTANCE		
	HOURS OF EXPOSURE		
	15.0	65.83	85.41
3A	0.008	0.005	0.015
3B	0.006	0.005	0.009
3C	0.002	0.010	0.020
2A	-0.009	-0.007	-0.006
2B	-0.005	-0.005	-0.008
2C	-0.007	-0.004	-0.009
1A	0.003	-0.005	0.004
1B	-0.001	-0.002	0.001
1C	0.007	0.011	0.009

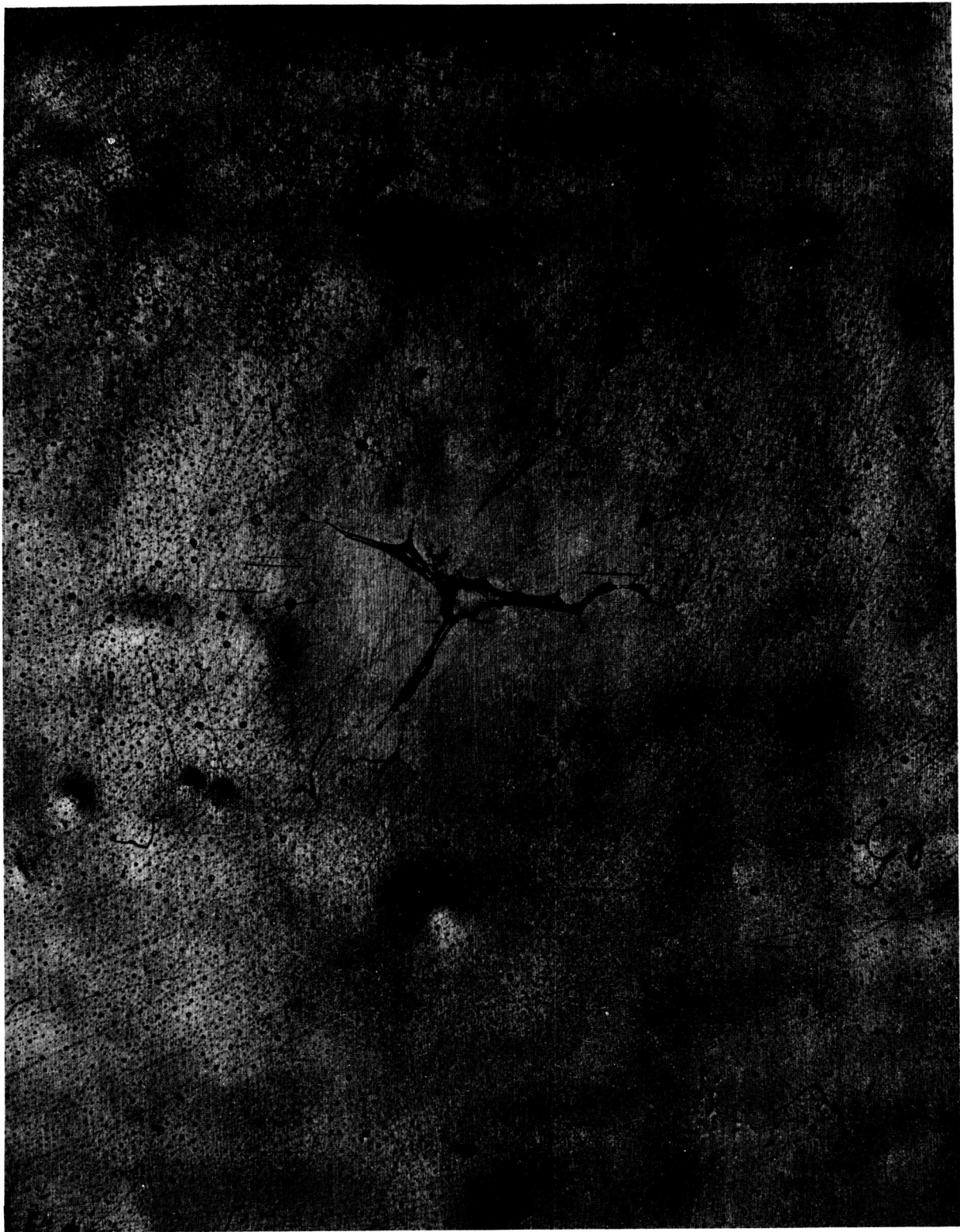


Figure 3 Photograph of the silver-Teflon sample 1C (area to the left of center), 1B (center area), 1A (area to the right of center) contaminated by the CVCN from RTV-560. Sample 1B was exposed to xenon vacuum ultraviolet radiation, 2.74 EUVS (147 nm); 1A and 1C

1B is the area in the center, and 1A is the area to the right of center. It appears that the intense vacuum ultraviolet causes the CVCM to collect in large droplets, effectively clearing the surface around it. The CVCM that remains after removing the samples from the vacuum chamber was not a uniform film but consists of various size droplets. Figure 4 shows a photograph (22x magnification) of sample 2C (area to the left of center), 2B (center area), and 2A (area to the right of center). These samples were all exposed to the X-25 solar simulator (2.32 ES). The clear area to the extreme right was that part of the sample which was under 3C. The vertical streaks were from an accidental brush by a gloved hand. Notice that the cross hatched area just to the right of center is similar to that found on sample 3A. Figure 5 shows a photograph (22x magnification) of sample 3C (area to the left of center), 3B (center area), and 3A (area to the right of center). No radiation was applied directly to this sample however some of the X-25 light can just strike the extreme left side of sample 3C. The spider web character of the CVCM on these samples differs from the droplets found on the samples irradiated with vacuum ultraviolet. Figure 6 shows a photograph of the control sample.

Table 7 presents the data for the change in α_s for a deposition level of $9.67 \times 10^{-6} \text{ g} \cdot \text{cm}^{-2}$, the RTV-560 reached a maximum temperature of 48°C . No reemission of the CVCM was measured and the silver-Teflon samples did not reach a temperature above -40°C for the entire test. Once again, the data does not show any strong trends. The irradiated samples, including 3A, 3B, and 3C which were exposed to the krypton lamp, did not show any different changes in α_s than the samples 2A, 2B, and 2C which were not exposed to any radiation. When the samples were brought back to room temperature, 58% of the CVCM had been reemitted. Visual inspection of the samples did not show any significant characteristic.

Table 7 Change in Solar Absorptance of Silver-Teflon Samples Contaminated by the CVCM of RTV-560 and Exposed to a Krypton Vacuum Ultraviolet Lamp 124 nm (3A,3B,3C), no Radiation (2A,2B,2C), and a Xenon Vacuum Ultraviolet Lamp 147 nm (1B, 2.74 EUVS; 1A,1C 0.062 EUVS). The Initial Deposition on the TQCM was $9.67 \times 10^{-6} \text{ g} \cdot \text{cm}^{-2}$ and no Reemission was Measured. All the Columns Show The Change in Solar Absorptance From the Initial Clean Value.

SAMPLE	CHANGE IN SOLAR ABSORPTANCE			
	HOURS OF EXPOSURE			
	0.00	3.67	21.17	64.76
3A	0.005	-0.001	-0.001	-0.003
3B	0.010	0.004	0.005	0.004
3B	0.013	-0.001	-0.002	-0.001
2A	-0.001	-0.010	-0.017	0.002
2B	0.008	-0.007	-0.012	0.003
2C	0.007	-0.015	-0.011	-0.005
1A	0.007	-0.012	-0.015	-0.015
1B	0.011	0.002	-0.012	-0.009
1C	0.003	0.004	-0.007	-0.010



Figure 4 Photograph of the silver-Teflon sample 2C (area to the left of center), 2B (center area), 2A (area to the right of center) contaminated by the CVCN from RTV-560 and exposed to 2.32 ES. Vertical streaks are from an accidental brush by a glove. The clear area to the extreme right was that part of the sample covered up by sample 3C.



Figure 5 Photograph of the silver-Teflon sample 3C (area to the left of center), 3B (center area), 3A (area to the right of center) contaminated by the CVCN from RTV-560. No radiation was applied directly to this sample, however some of the solar (2.32 ES) can just irradiate the extreme left side of sample 3C.

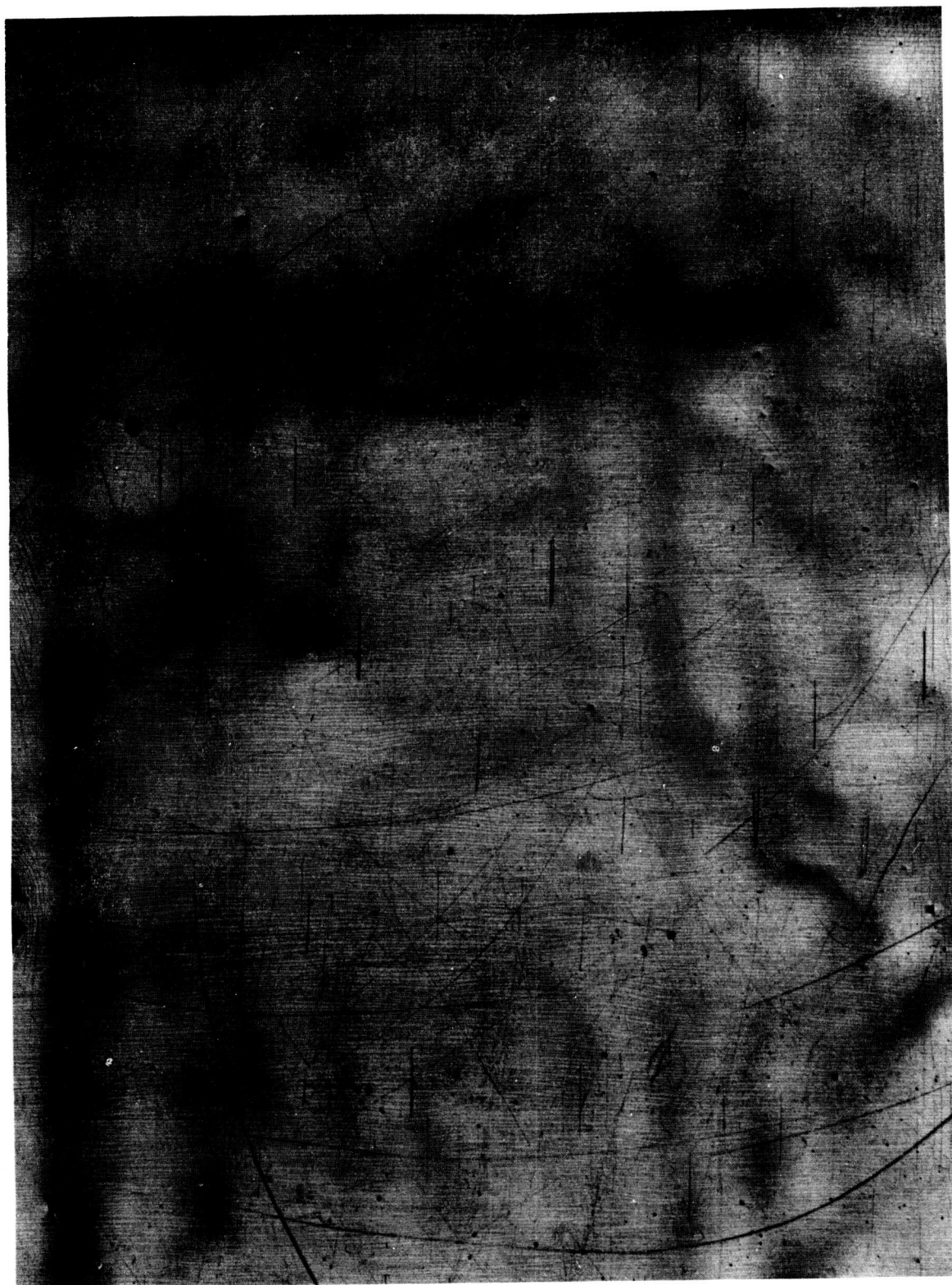


Figure 6 Photograph of the silver-Teflon control sample.

5.0 CONCLUSIONS

The stability of Ag/FEP to a vacuum environment and solar radiation, especially vacuum ultraviolet wavelengths, up to 370 EUVSH was verified. Although an undetermined geometrical factor produced solar absorptance values differing from the nominal 0.08, the sensitivity and repeatability of the instrumentation and analysis techniques were sufficient to determine a change of α_s by 0.01.

Temperatures below -40°C were necessary to inhibit significant reemission of the CVCM from RTV-560. The CVCM from a fresh RTV-560 source almost entirely reemits when the contaminated Ag/FEP reaches room temperature. RTV-560 sources that are used repeatedly produce a CVCM that will remain on the surface at room temperature, for one case 42% of the CVCM remained. The CVCM from RTV-560 is colorless and does not darken when exposed to solar radiation up to 2.74 EUVS for 370 EUVSH.

The change in α_s is not a linear function of the amount of CVCM. The major increase in α_s occurs for CVCM at least as small as a 28 nm equivalent film. Increasing the surface density of CVCM by a factor of 13 only increases the change in α_s by a factor of 2. An equivalent film of 370 nm only increases α_s by about 0.04. The solar absorptance of the contaminated Ag/FEP is not affected by solar radiation (wavelengths greater than 250 nm, 313 ESH) nor vacuum ultraviolet line emission (147 nm, 370 EUVSH; 124 nm, 82 EUVSH).

The CVCM from RTV-560 that remains on the Ag/FEP surface at room temperature is deposited uniformly in small droplets. The droplets can combine occupying a smaller surface area than the sum of the individual droplets. Intense vacuum ultraviolet enhances the formation of very large droplets. Thus, an initial increase in α_s can be decreased by both reemission of the CVCM and by large droplet formation reducing the effective contaminated surface area.